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Keyword:	General Laparoscopy, Technical, Education
Abstract:	<p>Aim To quantitatively determine whether a 3D image improves laparoscopic performance compared to a 2D image.</p> <p>Method A prospective study with two groups of participants: Novices(5) and Experts(5). Individuals within each group undertook a validated laparoscopic task on a box simulator, alternating between 2D and a 3D laparoscopic image until they had repeated the task 5 times with each imaging modality. A dedicated motion capture camera was used to determine the time taken to complete the task(s) and instrument distance travelled(m).</p> <p>Results Among the experts the mean time taken to perform the task on the 3D image was significantly quicker compared to the 2D image, 40.2s vs 51.2s, $P < 0.0001$. Among the novices the mean task time again was significantly quicker on the 3D image, 56.4s vs 82.7s , $p < 0.0001$. There was no significant difference in the mean time it took a novice to perform the task using a 3D camera compared to an expert on a 2D camera, 56.4s vs 51.3s, $p = 0.3341$.</p> <p>Conclusion The use of a 3D image confers a significant performance advantage over a 2D camera in quantitatively measured laparoscopic skills for both experts and novices. The use of a 3D image appears to improve a novices performance to the extent that it is not statistically different from an expert using a 2D image.</p>

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Does a 3D image improve laparoscopic motor skills?

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Running head: Does a 3D image improve laparoscopic motor skills?

Aim

To quantitatively determine whether a 3D image improves laparoscopic performance compared to a 2D image.

Method

A prospective study with two groups of participants: Novices(5) and Experts(5). Individuals within each group undertook a validated laparoscopic task on a box simulator, alternating between 2D and a 3D laparoscopic image until they had repeated the task 5 times with each imaging modality.

A dedicated motion capture camera was used to determine the time taken to complete the task(s) and instrument distance travelled(m).

Results

Among the experts the mean time taken to perform the task on the 3D image was significantly quicker compared to the 2D image, 40.2s vs 51.2s, $P < 0.0001$.

Among the novices the mean task time again was significantly quicker on the 3D image, 56.4s vs 82.7s , $p < 0.0001$.

There was no significant difference in the mean time it took a novice to perform the task using a 3D camera compared to an expert on a 2D camera, 56.4s vs 51.3s, $p = 0.3341$.

Conclusion

The use of a 3D image confers a significant performance advantage over a 2D camera in quantitatively measured laparoscopic skills for both experts and novices. The use of a 3D image appears to improve a novices performance to the extent that it is not statistically different from an expert using a 2D image.

INTRODUCTION

One of the technical challenges of laparoscopy is the loss of depth perception that using a 2D camera and image processing entails. Experienced laparoscopic surgeons develop strategies to adjust for this loss of stereotactic vision, but novices often struggle initially.

There is a growing interest in 3D laparoscopic equipment to overcome this barrier, however there are few studies that directly compare the performance of a 3D image with a 2D image using quantitative motion capture techniques. [1].

A recently published systematic review of 3D versus 2D vision in laparoscopy concluded that overall, 3D laparoscopic appears to improve speed and reduce the number of performance errors when compared to 2D laparoscopy [2].

The potential benefits of simulated 3D laparoscopy as a training tool for prospective surgeons has been highlighted by Votanopoulos et al [3] who were able to demonstrate that 3D offered significant advantages in the teaching of laparoscopic skills to inexperienced individuals.

We have previously described a validated laparoscopic simulated task to test one’s laparoscopic skills [4] and the novel ‘InsTrac’ instrument-tracking software that is able to give objective feedback on one’s laparoscopic performance [5].

The aim of this study was to quantitatively determine whether a 3D image improves laparoscopic performance compared to a 2D image and what effect it has on the learning curve, using a validated laparoscopic task and motion capture technology.

MATERIALS AND METHODS

A prospective study with two groups of participants: Novices(5) and Experts(5). Novices were defined as junior doctors or medical students with no prior laparoscopic experience. Experts were defined as surgical trainees or consultants with 50 or more independent laparoscopic cases.

The laparoscopic task and simulator used in this study have been previously validated [4] as has the ‘InsTrac’ instrument-tracking software [5].

Individuals within each group undertook a validated laparoscopic task (threading a string through a series of five hoops) on an eoSim (eoSurgical™ Ltd., Edinburgh, Scotland, United Kingdom) laparoscopic simulator, alternating between 2D and a 3D laparoscopic image on the same camera until they had repeated the task 5 times with each imaging modality. The camera position was fixed in a standard position for all the participants. The start point was with the tips of the left and right hand laparoscopic graspers held just outside the ports. The end point was the removal of the laparoscopic instruments from the simulator on completion of the task. (Figures 1 and 2).

Using a dedicated motion capture camera, data collected included time taken to complete the task(s) and instrument distance travelled(m).

Statistics were performed using Stats Direct 2.7.8 (Stats Direct Ltd, Altrincham, Cheshire, UK). A paired t-test was used to compare the performance on a 2D vs 3D image within each group. An unpaired t-test was used to compare the performance between the two groups on a 2D and a 3D laparoscopic image.

RESULTS

Among the experts the mean time taken to perform the task on the 3D image was significantly quicker compared to the 2D image, 40.2s (35.1-45.3, 95% CI) vs 51.2s (44.4-58.1, 95% CI), $P < 0.0001$.

Among the novices the mean task time again was significantly quicker on the 3D image, 56.4s (27-114, 95% CI) vs 82.7s (41-207, 95% CI), $p < 0.0001$.

There was no significant difference in the mean time it took a novice to perform the task using a 3D camera compared to an expert on a 2D camera, 56.4s (27 - 114, 95% CI) vs 51.3s (29 - 80, 95% CI), $p = 0.3341$.

Among experts there was no significant difference in the distance travelled with the laparoscopic instruments when using a 2D image compared to a 3D, 1.08m (0.64-1.86, 95% CI) vs 1.01m (0.58-1.6, 95% CI), $p = 0.2721$

Among novices there was a significant difference in the distance travelled between 2D and 3D camera use, 1.37m (0.61-3.59, 95% CI) vs 1.12m (0.64-2.23, 95% CI), $P = 0.0193$. (Figure 3)

DISCUSSION

Our study demonstrates that there is a clear advantage of a 3D image over a 2D image in the performance of a laparoscopic task, with regards to the time taken to complete the task and the reduction of the learning curve particularly for novices. Expert surgeons were able to perform the laparoscopic task significantly quicker using a 3D camera as opposed to a 2D (40.2s vs 51.2s, $p < 0.0001$). The explanation for this is multifold, the 3D image confers a superior depth perception, thereby enabling the subject to position the thread in the hoops with greater precision ultimately leading the quicker task completion time.

It was striking to see that there was no significant difference in the mean time it took a novice to perform the task using a 3D camera compared to an expert on a 2D camera, (56.4s vs 51.3s, $p = 0.3341$). The obvious interpretation of this result is that a 3D laparoscopic image enables a novice surgeon to perform a simple task to the same level in terms of completion time as an expert surgeon using a 2D laparoscopic image. This could have implications for future surgical training in that the learning curve for laparoscopic training and performance could be shortened for trainees by the use of a 3D laparoscopic camera as opposed to a 2D image.

There have been a number of studies demonstrating that 3D laparoscopy confers a shorter operating time, a shorter learning curve as well as better depth perception [6, 7, 8]. Where this study stands out is that we have made a direct comparison between the novices and experts and have demonstrated that the rate of acquisition of laparoscopic skill fostered by the use of a 3D laparoscopic camera can propel a novice surgeon to the same level as an expert surgeon using a 2D laparoscopic camera in the performance of a given task.

Interestingly the use of the 3D image resulted in a shorter distance being travelled to complete the task compared to a 2D image, for novices but not for experts. This could be due to the fact that the number of subjects tested was not big enough to detect a difference if there indeed was a difference. Also it could be attributed to the experts being able to adapt better and compensate for the inferior image because of their superior baseline laparoscopic skills set. Additionally the experts have become experts on 2D laparoscopic image, hence they are preconditioned to working with a 2D laparoscopic image and would have made adjustments throughout their years of training to compensate for the shortcomings of the 2D laparoscopic image. On the contrary novices without any prior laparoscopic experiences would be better subjects at bringing to the fore the superiority of one image modality over the other because they would not have had years of preconditioning and adaptation to one image modality.

Despite the fact that the 'InsTrac' instrument-tracking software is capable of measuring the average speed (mm/s), average acceleration (mm/s²), average motion smoothness (mm/s³), percentage off screen and handedness, in addition to the time taken to complete the task and instrument path distance. We decided to focus on the last two metrics as these have been identified as the key performance metrics for laparoscopic skills assessment [9].

CONCLUSION

The use of a 3D image confers a significant performance advantage over a 2D camera in quantitatively measured laparoscopic skills for both experts and novices. The use of a 3D image appears to improve a novices performance to the extent that it is not statistically different from an expert using a 2D image.

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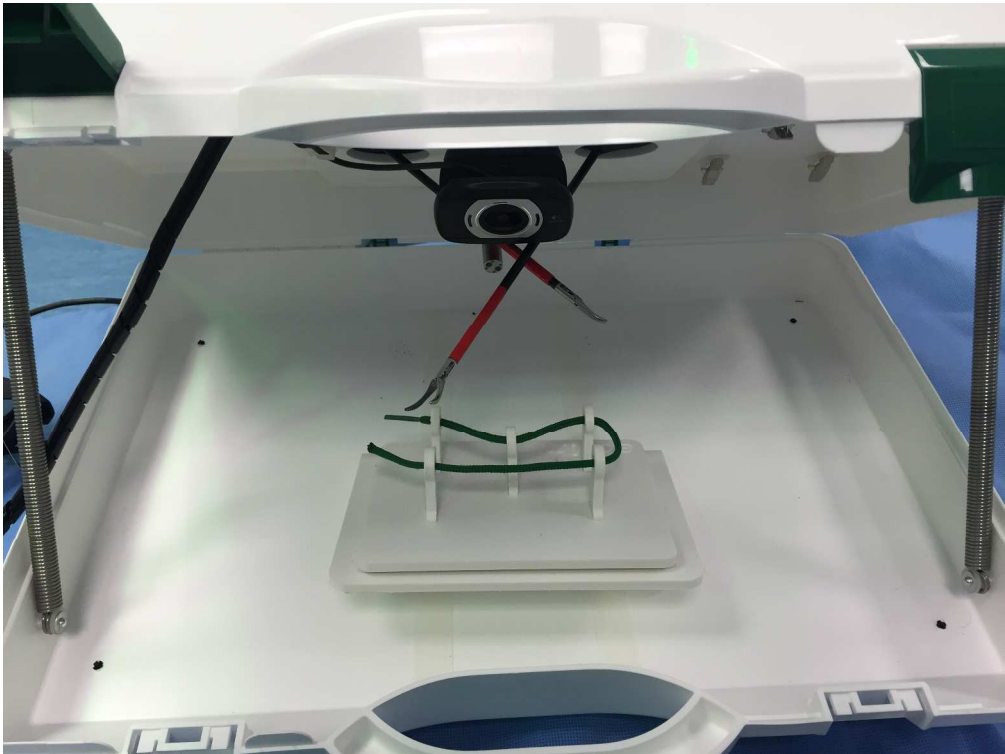
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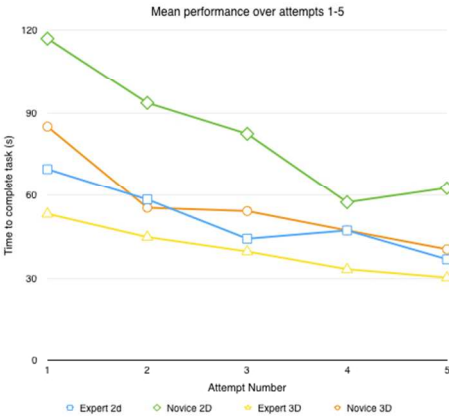


Laparoscopic task showing the thread passed through the five hoops.
1151x863mm (72 x 72 DPI)



Standard configuration of 2D/3D camera and the eoSim laparoscopic simulator box fitted with 'InsTrac' software.

1151x863mm (72 x 72 DPI)



Graph of mean time to complete task.
361x270mm (72 x 72 DPI)